

1. (i) potometer; **R** '*transpirometer*' 1
- (ii) transpiration is the loss of water, vapour/by evaporation;
(apparatus) measures water uptake;
to replace loss;
assumes all uptake is lost/AW; or a some may be used
explanation of how some uptake may be used e.g. used to regain
turgor/used in photosynthesis;
uptake by detached shoot may not be same as whole plant/AW; 3 max
- (iii) cut shoot under water/insert into apparatus under water/AW;
cut shoot at a slant;
no, airlocks/bubbles/AW in, plant/apparatus, **or** airtight/watertight, joints;
dry off leaves/AW; use a healthy/undamaged/AW, shoot; **A** *fresh*
allow time to acclimatise/AW;
keep (named) condition(s) constant; **R** '*control*' *conditions if unqualified*
measure per unit time;
AVP; e.g. reference to scale, qualified – note position/fix scale
R '*set at 0*'
qualified reference to reservoir
R *repeat readings – gives reliable results not valid readings* 4 max
2. (i) 1 temperature increased;
more KE/energy/AW;
more evaporation/faster diffusion; **R** *transpiration max 3*
- 2 light (intensity) increased; **A** *sunlight* but **R** '*sun*' but ecf
stomata opened (wider);
allowed more water vapour out/AW;
must be linked to stomatal point above
temp increase linked to light; *max 3*
- 3 humidity dropped/air less saturated/AW;
internal spaces c. 100% saturated/AW;
steeper water potential gradient/AW; **A** *diffusion gradient*
R *concentration gradient max 3*
- 4 wind (increased);
removed, saturated air/diffusion shells/AW;
steeper water potential gradient/AW;
A *diffusion* **R** *conc gradient max 3*
- Score the first two explanations given to a max of 4* 4 max

[8]

- (ii) 1 **P** has, many/more, leaves;
(so total) area (of leaves) greater;
(so) more, area for transpiration/evaporation/stomata;
- or**
- 2 **P** has more stomata;
idea that stomata are (main) site/AW, of transpiration/evaporation;
- or**
- 3 **Q** has a stated xerophytic modification;
R *Q is a xerophyte, if unqualified*
R *Q has smaller/AW leaves*
explanation of modification; needs how it reduces transpiration
e.g. hairs – wind barrier/stops water vapour removal
sunken stomata – traps water vapour/AW
thick cuticle/wax/AW reduces loss/AW **R** *stops all loss*
curled leaves – trapping water vapour idea 2 max

Apply ora throughout.

[6]

3. (a) **C**;
E; 2
- (b) large surface area (to volume) / many;
low water potential; **A** ref to low solute potential
R refs to water concentration
A refs to (high) solute concentration
thin wall / short diffusion path;
uncuticised / permeable / unlignified / AW;
rapid, growth / replacement; 2 max

- (c) 1 osmosis in correct context;
look for across membrane, or, into / out of, cell / root
- 2 moves down a water potential gradient / from high to low
water potential;
R along / across **R** concentration / diffusion gradients
- 3 most negative / lowest, in the xylem;
- 4 (uptake of) ions / minerals / solutes, into xylem / root hair;
in context of WP gradient
- 5 tension in xylem / transpiration pull / cohesion-tension;
relate to pathway in root
- 6 (moves) via the cell walls;
- 7 (moves) via, cytoplasm / vacuoles;
- 8 passage via the plasmodesmata; *look for linking cytoplasm /
through wall*
- 9 Casparian strip / suberin / waxy / fatty / AW, blocks,
cell wall route / apoplast; **A** waterproof
- 10 water, crosses membrane / enters, cytoplasm / vacuole / symplast;
- 11 AVP; e.g. pits in xylem / passage cells / aquaporins /
protein channels / capillarity in cell wall (spaces) max 6
- credit points from diagram*
- QWC – legible text with accurate spelling, punctuation and grammar;** 1

- (d) 1 for feature and 1 for role in each section **except lignin** but max 2 for features and max 2 for functions
apply AW throughout

lignin / AW;

(allows) adhesion / waterproof / stops collapse (under tension);

A two functions

rings / spirals / thickening / AW; **A** thick wall / rigid sides

prevents collapse (under tension); **R** strong / support / stops bursting

no cytoplasm / lack of contents / hollow / (empty) lumen / AW;

R “dead” unqualified

less resistance to flow / ease of flow / AW / more space (linked to lack of contents);

lack of end walls / continuous tube; **A** long tube idea

less resistance to flow / ease of flow; **A** continuous columns idea

pits / pores, inside walls; **A** holes **R** gaps

lateral movement / get round air bubbles / supplies(water) to cells or tissues / water in or out; **R** “just let things in and out” unqualified

develop as a continuous water-filled column / AW;

allows tension to pull water up / AW;

narrow lumen / AW;

idea of more capillary rise;

4

[15]

4. **G;**
I;

2

[2]

5. (i) evaporation of water / water vapour lost (from plants);
diffusion,
into atmosphere / out of leaf / down a water potential gradient /
via stomata;
A high to low water potential references
*stop if / when candidate says transpiration is ‘upward movement of
water in plant’*

2 max

- (ii) linked to gas exchange / AW; **A** refs to **both** oxygen and carbon
dioxide unqualified carbon dioxide for photosynthesis;
open stomata;
large area; *can apply to leaf area or pore area*
moist mesophyll to (relatively) dry air / water potential gradient / AW;
AVP; e.g. ref to some cuticular transpiration inevitable / AW
link open stomata to daytime when it is hottest / AW

3 max

- (iii) hairs trap water vapour; **R** water unqualified / water particles **A** molecules
 reduces water potential gradient / stops wind removing vapour /
 more humid air around leaf; *ecf* for water
 so less transpiration / **AW**;
AVP; e.g. ref reflective nature of hairs in context
 ref to need of xerophytes to conserve water in dry habitat 2 max

[7]

6. 1 in the xylem vessels; **A** tracheids
 2 down a, water potential / Ψ , gradient;
R 'along' **A** refs to high to low water potential
 3 most negative, at the leaf / in the atmosphere;
ora must refer to water potential
 4 transpiration sets up a gradient / **AW**; *any valid gradient*
 5 (places) water (in xylem) under, tension / suction / negative pressure /
 pull / hydrostatic pressure gradient / **AW**;
 6 cohesion;
 7 description of cohesion;
 8 ref to hydrogen bonding;
 9 (continuous) water columns / **AW**;
 10 mass flow;
 11 root pressure, in context / described;
 12 adhesion described / capillarity;
treat refs to osmosis and descriptions of passage through root as neutral 6 max
QWC – legible text with accurate spelling, punctuation and grammar; 1

[7]

7. (i) stem; 1
 (ii) **B**; 1

[2]

8. (a) sucrose; 1
- (b) (i) **P** = companion (cell);
Q = sieve (tube) element / sieve tube cell; **R** sieve tube / sieve cell 2
- (ii) *ecf - do not penalise sieve tube here*
- 1 sieve elements / **Q**, end to end *or* sieve plates perforated / sieve pores , for ease of flow / AW;
 - 2 companion cells / **P**, metabolically active / have many mitochondria / produce ATP / release energy / AW; **R** make energy
 - 3 (active) loading into, companion cell / **P**; **A** into, sieve elements / **Q**
 - 4 ref to proton pump;
 - 5 ref to co-transporter;
 - 6 role of plasmodesmata (between **P** and **Q**); **R** pores
 - 7 sieve element / **Q**, has few organelles / AW, for, ease of flow / more sucrose / AW;
 - 8 ref to, unloading mechanism / (hydrostatic) pressure gradient;
 - 9 ref to one role for sieve plate e.g. electro-osmosis or stops 'bulging'; 3 max

[6]

9. source when root converts, starch / insoluble carbohydrate, into sugars / AW;
sink when root **either** stores starch / (named) carbohydrate / assimilate
or uses carbohydrate for, respiration / growth / AW;
high hydrostatic pressure makes it a source **and** low hydrostatic pressure a sink;
when loading it is a source **and** when unloading a sink;
treat refs to (potato) tubers as neutral 2 max

[2]

10. water potential; **A** symbol **R** other gradients
apoplast / apoplastic; **A** apoplasm **R** anoplast
endodermis / Casparian strip; **A** starch sheath **R** stele
Casparian strip / suberin / AW; *only credit Casparian strip once*
symplast / symplastic; **A** vacuolar / symplasm / synplast
A endodermis in point 4 if point 3 is blank or neutral
if more than one response in a gap, take first on list for points 1, 3 and 4.
*For apoplast and symplast look for single term i.e. **R** if put apoplast / symplast*

[5]

11. 3 to 5 armed star of xylem with phloem more or less between;
R if star too close to the edge
 xylem and phloem correctly labelled;
ecf - if stem drawn, credit correct xylem and phloem labels 2 [2]
12. lack of contents / no cytoplasm / hollow / lumen / continuous / AW;
A lack of end walls
 less resistance to flow / more space linked to idea of lack of contents / AW;
treat large as neutral
 thickening / rings / spirals / lignin (in the wall); *treat cellulose as neutral*
 prevents collapse / gives support / adhesion of water;
R strength / rigid, unqualified **R** ideas on resisting positive pressure
 pits / AW; **A** pores / holes (in side walls)
 allow lateral movement / AW; **R** 'let things in or out' unqualified 4 max [4]
13. (i) *source* – leaf / storage organ / named storage organ; **A** root qualified
sink – root / tuber / storage organ / (young) growing region / leaf
 qualified / flower / bud / fruit / seed;
R individual cells but **A** tissue areas such as mesophyll 2
- (ii) *max 2 if no reference to diagram*
 water will enter source;
 by osmosis;
 down / AW, a water potential gradient;
 increase in (hydrostatic) pressure;
 as source / sink cannot expand / AW;
 force / AW, solution along (tube to sink);
 AVP; e.g. explanation of mass flow 4 max [6]
14. (i) ATP involved / respiration involved / many mitochondria in companion
 cells / reduced by metabolic inhibitors / oxygen dependent / temperature
 dependent / loading against a concentration gradient / AVP;
if evidence not given here look for it and credit it in part (ii) 1

- (ii) loading, into companion cell / from transfer cell / into sieve tube / into phloem – implied;
 H ions / protons, pumped out of, companion cell / sieve tube / phloem;
 diffuse back in with sucrose;
 protein carrier / co-transporter;
 possible active unloading by reverse mechanism;
 AVP to cover alternative mechanisms;;;
 e.g. electro-osmotic theory
 K⁺ pump
 via companion cell
 electrochemical gradient
 sieve pores provide a capillary bed / AW

3 max

[4]

15. (i) cut shoot under water;
 insert into apparatus under water / AW;
 full of water / no extra bubbles / no airlocks; *applies to plant / apparatus*
 cut shoot at a slant;
 dry off leaves / AW;
 ensure , air- / water- , tight joints / AW;
 use a , healthy / AW , shoot :
 allow time to acclimatise / AW;
 keep , condition(s) / named condition(s) , constant;
 measure per unit time / AW;
 shut screw clip;
 ref to scale; e.g. note where bubble is at start / keep ruler fixed
R 'move bubble to end' ideas

4 max

- (ii) water uptake / AW; **R** water used

1

[5]

16. (a) (i) 103; **R** decimals

1

- (ii) **R** refs to water or water particles

- 1 boundary layer / saturated air / water vapour / AW, around, leaf in still air / **A**;
- 2 (which) fan / wind , removes / reduces;
ecf wrong ref to water
- 3 ref steeper water potential gradient;
R concentration gradient
- 4 (therefore) faster / greater / more / AW, evaporation / diffusion;
must be linked to above

3 max

- (b) set up in same, (environmental) condition(s) / named condition;
 calculate the rate per unit area of leaf / idea of getting same area
 of leaf in both;
 detail of how this could be done; e.g. draw round all leaves on graph paper
 replicates;
 both picked at same time / same degree of turgidity / AW;
 run for the same time / AW;

2 max

[6]

17. water moves down a water potential gradient / AW;
 by osmosis;
 (ref to roots being below -50 kPa means) water will enter (the root);

2 max

[2]

18. *function must match adaptation, adaptation can stand alone*
assume answer is about water vapour unless clearly wrong e.g. water droplets

covered in hairs;
 reflect heat *or* water vapour, trapped / not blown away;
 thick, waxy layer / cuticle / AW;
 reduces loss (via the epidermis) / reflects heat; **R** no loss
if cuticle related to reflective nature, 'thick' not needed
 small / AW, leaves; **A** no leaves (e.g. cacti) / needles / spines / spikes **R** thorns
 reduced surface area for loss / reduces number of stomata;
R ref to spines etc related to preventing consumption by herbivores

sunken stomata / AW; **A** substomatal chamber hairs as an alternative here
 water vapour, trapped / not blown away;

rolling up of leaves / curled leaves;
 less surface area / stomata on inside *or* water vapour, trapped / not blown away;

small air spaces in the mesophyll;
 quickly become fully saturated / reduced area for loss;

stomata, shut in day / open at night / AW;
 day hotter / night cooler;

AVP; e.g. reduced stomatal number plus reason
 AVP; timed leaf fall
 rosette of leaves close to ground

4 max

[4]

19. (a) stem; 1
 (b) phloem; **R** sieve tube, phloem vessel, single cell type 1
 (c) **C**; 1

- (d) *feature and role must match for 2 marks*
mark for feature may be awarded even if role is incorrect
both marks may be given in right hand column.

Feature *how it helps*

*either **D** or **E***

living;	allows active process / AW; stops escape of metabolites;
hydrogen pump / co-transporter;	(role in) loading / AW;
plasmodesmata / connections between sieve tube and companion cell;	allow exchange /AW;

D / companion cell

(many) mitochondria	provide, energy / ATP;
much respiration / metabolically active;	
nucleus;	controls functioning of both cells;

E / sieve tube

clear of most organelles /	less resistance / ease of transport
organelles at edge / little cytoplasm / AW;	/ AW / more space for transport;
R empty	
<i>(if specific organelles given, need at least 2)</i>	
long / elongated / AW;	less resistance / ease of transport / AW;
sieve plate / (sieve) pores;	connects elements / lets materials through / AW; A reduces resistance
joined end to end;	continuous / long distance, transport;
bi-directional flow;	allows sugar to go to sink both up and downward / AW; 6 max

[9]

20. mark for transpiration / evaporation is not freestanding, in each case it must be related to the feature in each section

(a) transpiration / evaporation / AW, occurs via stomata; **R** water loss (generally) warm(er) in day;
more evaporation / transpiration will occur (in context);
ref. to steeper water potential gradient;
shutting, stops / reduces, this loss;
ora for open at night 2 max

(b) small surface area;
less transpiration / evaporation / AW (in context);
R water loss **R** no transpiration
fewer stomata / AW;
protection against grazing / AW; 2 max

(c) hairs trap, water vapour / moisture in air; **R** just moisture
prevent wind effect / AW;
reduces water potential gradient;
less, transpiration / evaporation / AW (in context);
R water loss **R** no transpiration
correct ref. to condensation of water vapour; 2 max

[6]

21. (i) loss, of water vapour / by evaporation;
diffusion into, atmosphere / air / environment / out of plant;
via stomata *or* from, leaves / aerial parts;
max 1 if response starts with 'transpiration is the upward movement of water' 2 max

(ii) *Descriptions*
1 increases then decreases / peaks / higher by day / lower by night;
2 correct ref to figures to support e.g. highest at 1400 / lowest at midnight / ref to one rate with units;
Comparisons
3 (rate of) transpiration greater, in day/ when hotter / 6 to 16 hours; *ora*
4 (rate of) transpiration less, at night / when cooler / 16 to 6 hours; *ora*
5 rates equal at 6 and 16 hours;
6 both peak, at the same time / at 14 hours / accept midday; / AW;
7 both lowest at, same time / midnight;
8 transpiration rise is steeper; *ora*
9 transpiration fall is steeper; *ora*
10 any one figure quote for rate with units that supports comparison points above; 4 max

- (iii) award two marks if correct answer (58) is given – must be rounded up 58 (%);;
 max 1 if not whole number, award calculation mark for getting 14 hours
 ecf If wrong time period read, but correct % calculated from it = 1 mark 2 [8]

22. loss of water from mesophyll;
 cell walls;
 more drawn from, cytoplasm / cell / AW;
 cohesion of water molecules;
 hydrogen / H, bonds;
 water under tension / ref to hydrostatic pressure gradient implied;
 A water 'pulled' / 'drawn' R sucked
 via, symplast / apoplast / vacuoles / description / AW;
 (water from) xylem / xylem vessels;
 ref to water potential gradient; 4 max [4]

23. (a) water uptake / AW; R water used 1
- (b) 1 cut (healthy) shoot under water (to stop air entering xylem vessels);
 2 cut shoot at a slant (to increase surface area);
 3 check apparatus is full of water / is air bubble free / no air locks;
 4 insert shoot into apparatus under water / AW;
 5 remove potometer from water and ensure , airtight / watertight, joints around shoot;
 6 dry leaves / AW; max 4
 7 keep , condition(s) / named condition(s) , constant;
 8 allow time for shoot to acclimatise / AW;
 9 shut screw clip;
 10 keep ruler fixed and record position of air bubble on scale;
 R 'move bubble to end' ideas
 11 start timing and, measure / calculate, distance moved per unit time / AW; max 3 [8]

24. (i) 103; R decimals 1
- (ii) plant A
- hairs around stoma;
 trap, moisture / water vapour;
 reduces the water potential gradient;
 so transpiration rate is reduced; max 3 [4]